coastline

The Adelaide Metropolitan Coastline

SOUTH AUSTRALIAN COAST PROTECTION BOARD

No. 27
April 1993

Brighton and Seacliff c. 1900

Brighton and Seacliff 1993

INTRODUCTION

European settlement of the Adelaide region began in the 1830's. The site had been selected based on the extensive exploration and investigation of the coastline by Colonel Light. In making a final decision, Colonel Light was probably influenced by the wide belt of coastal dunes and wide sandy beaches stretching to the north and south. In fact, there was a continuous 30 kilometre stretch of sand dunes reaching from Seacliff to Outer Harbor, broken only at the Patawalonga Creek. These ranged in height up to'15 metres and averaged a width of between 200 and 300 metres. The Adelaide region included the coastal dunes, and offered settlers an abundant source of building materials, grazing land, timber for fuel, and residential land.

As metropolitan settlement has expanded, particularly since the 1920's, much of this dune belt has been developed for residential purposes. Much of this foreshore development occurred in the 1940's, and major storms in the 1940's and 50's highlighted that the metropolitan coastline was far from stable. These storms created widespread damage to properties along the foreshore, and increased public awareness about the need to protect both public and private property due to the effects of the natural coastal processes.

In 1972 the Coast Protection Act was passed by parliament. It established a Coast Protection Board to provide management expertise not only for the metropolitan beaches but for the entire 4,000 kilometres of the South Australian coastline. However, the coastal erosion and encroachment of development within the Adelaide region has meant that the metropolitan beaches continue to require considerable research and management attention. It should be noted that the Coast Protection Act is currently under review and revised legislation is expected to be debated by parliament late in 1993.

Storm Damage - Glenelg, 1964

GEOMORPHOLOGICAL HISTORY OF THE METROPOLITAN COAST

Prior to the Tertiary period (ie more than 100 million years ago), geological history records Australia as being connected to the Antarctica land mass, as part of Gondwanaland. This land mass was primarily above sea level. At the start of the Tertiary period a succession of extreme climatic cycles had weathered and eroded parts of the land mass. Australia separated from Gondwanaland about 55 million years ago. The separation occurred along what is now the southern boundary of the Australian continent, and can be likened to pulling a piece of toffee or chewing gum apart. It thinned the land mass between the two continents and permitted the sea to inundate land areas which had been free of the ocean for hundreds of millions of years. This distortion led to a series of basins being formed. The St Vincent basin, on which Adelaide is now located is one of these areas.

The separating of the land masses reactivated ancient weaknesses in the land surface. In the St Vincent basin, north-south fault planes enabled a series of step-like blocks to be formed; the eastern blocks rising to form the Adelaide Hills. Initially the upliftings were gentle and the eroded sediments were deposited as sands in freshwater lakes and swamps. However, about 40 million years ago the land movements became more severe. Differential movements along the active fault planes allowed the western blocks in the St Vincent basin to sink rapidly below the existing sea level. The initial marine sediments deposited on the floor of the basin were largely composed of sands. These fault movements are still occurring today, but at a much slower rate.

Around 2 million years ago, at the end of the Tertiary period, world climatic patterns began to change. A series of glacial and interglacial periods caused major fluctuations in the sea level, resulting in rapid withdrawals and returns of sea in areas like St Vincent basin. During the last period of very low sea level, about 18,000 years ago, the sea level is presumed to have retreated to the edge of the continental shelf. The sea levels were up to 120 metres below the present sea level. At this time the St Vincent basin would have formed a shallow valley through which flowed a river with the present Torrens River and Onkaparinga River acting as tributaries.

From about 15,000 years ago to 10,000 years ago, at the end of the last great Ice Age, there began a large rise in the eustatic sea level which again flooded the basin; to form the Gulf St Vincent. Waves eroded the newly flooded seafloor and transported the eroded sediment onto the coast forming beaches and sand dunes.

Between 6,500 to 4,000 years ago the sea level rise slowed considerably. At the end of this time the sea level had reached approximately its present level. It was largely during this period that the

dunes and beaches along the Adelaide coast were formed. Over the last 4,000 years the sediment supply from these offshore sources has declined to the point where virtually no sediment is being transported ashore.

This brief geomorphological history of the formation of the metropolitan sand dune system should indicate that the processes involved in forming the metropolitan coastal dune have involved a long time period, particularly in terms of the expected life span of a human being. The process has required the supply of sand from an offshore sand source which is no longer available to supplement the existing eroding dune system. Unlike other dune systems elsewhere in the world, the supply of land based alluvial sediments to the Adelaide sand dune system is limited and is certainly not sufficient to supplement the losses occurring due to the current coastal erosion.

It is worth noting that there is still an ongoing rise in mean sea level occurring throughout the world. The Tidal Laboratory of the Flinders Institute for Atmospheric and Marine Sciences has an ongoing role in data collection and researching changes in sea level. Current indications are that there is a continuing rise in sea level of approximately 1.5 millimetres per year, but this rate is expected to increase due to the Greenhouse Effect. The relatively young sediments on the Adelaide Plains are also still consolidating and it is estimated that the land is subsiding or settling by about 0.5 millimetres per year relative to the sea level. Based on current data and knowledge, the Government has accepted the Coast Protection Board's recommendation that allowance be made for 0.3 metre rise in mean sea level from the year 1991 to 2030, and a further 0.7 metre rise from 2030 to 2100. This is detailed further in the Board's policy document and summarised in Coastline No. 26.

THE DUNE SYSTEM AT THE TIME OF FIRST EUROPEAN SETTLEMENT

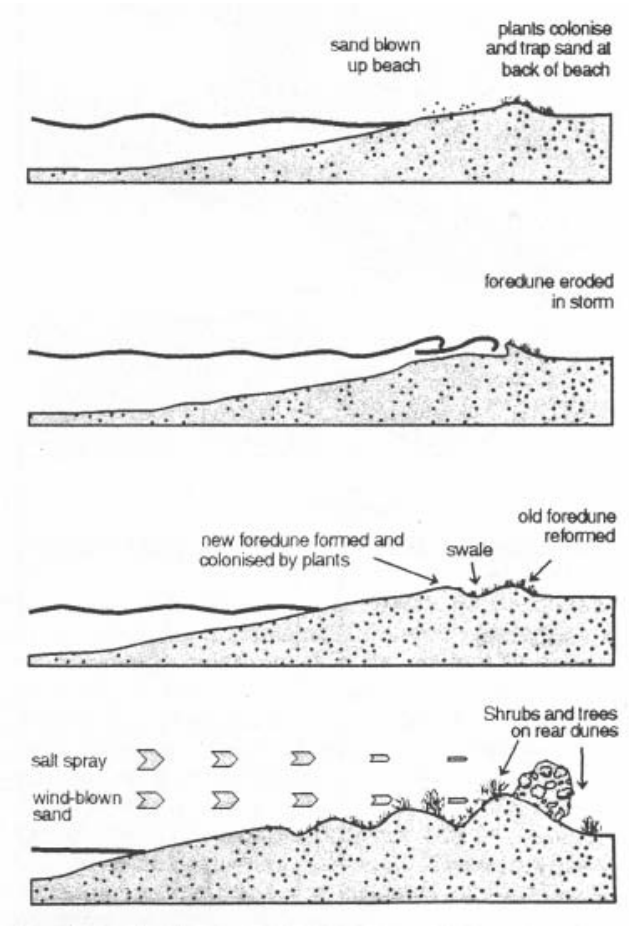
Up until the late 1800's, the continuous sand ridges flanked the coastline west of Adelaide from Seacliff to Outer Harbor. Between Seacliff and Largs this dune belt was regular and even, averaging between 200 and 300 metres in width. It was broken only at Glenelg, where the Patawalonga entered the sea. The River Torrens flowed into a series of swamps lying behind the coastal dunes and drained both north and south to the sea through the Patawalonga and the Port River. This stretch of sand dune comprised 2 or 3 parallel ridges, each about 70 to 100 metres wide, separated by narrow depressions or swales.

The only remaining relics of this are a short section just south of the Oval at Minda Home and at West Lakes near Estcourt House. The first line of dunes rose sharply, immediately eastward of the highest tidal limits, and generally the sand ridges had a steep slope on the landward or lee side. The average height of the dunes was 10-12 metres, the tallest being at Brighton and at about 3 kilometres north of the Grange Jetty, where they reached about 15 metres. In places the silicious Holocene sand hills were bare and consisted of shifting white sand, but for the most part, they were covered with sand-binding vegetation.

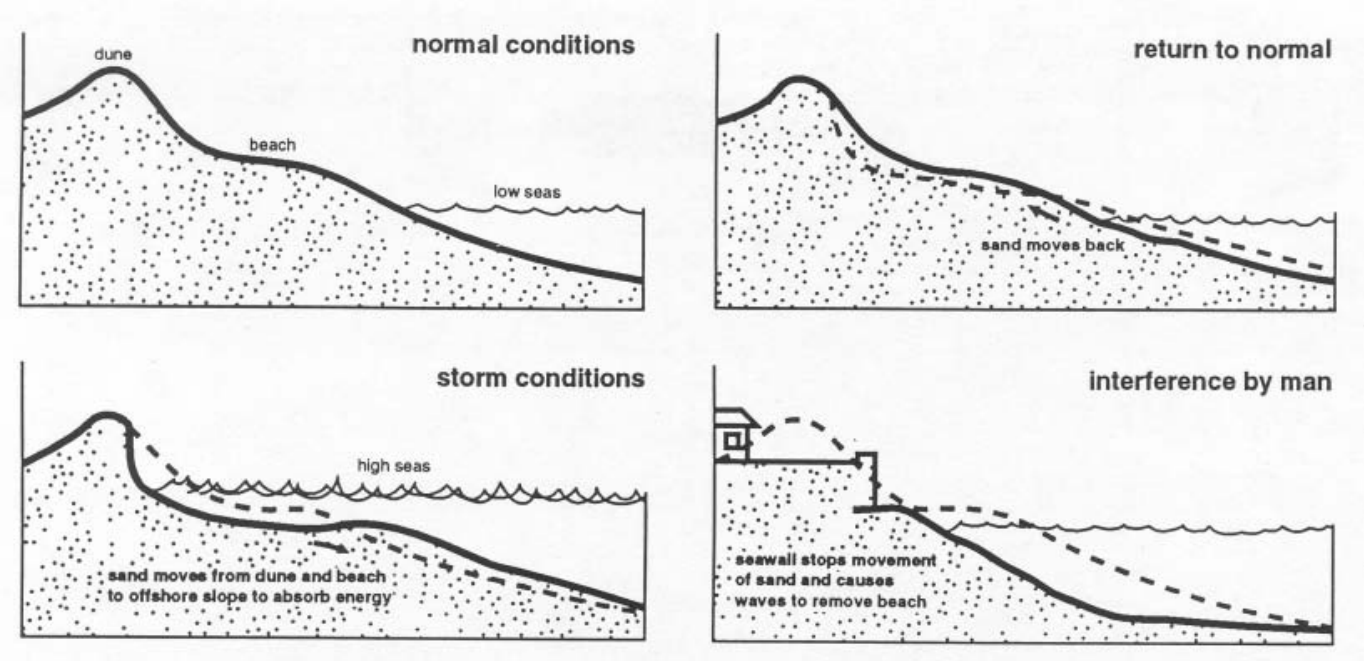
EUROPEAN SETTLEMENT ON THE DUNE SYSTEM

While Colonel Light had envisaged the Port River as the logical site for expanded harbour facilities, the actual landing at Adelaide by Governor Hindmarsh and the first settlers occurred at Holdfast Bay. The first settlers would have seen a series of high and wide dunes. There was probably little concern given to these dunes, and probably no understanding of their importance, because the sand would have appeared in infinite supply. So began the process of dune deterioration and removal.

It was soon found that the removal of vegetation, by either grazing stock, builders or mining caused sand drifts. A vivid example of this was the construction of a railway line by the "Glenelg and South Coast Tramway Co." in 1879 to service trade between the Brighton and Glenelg areas.



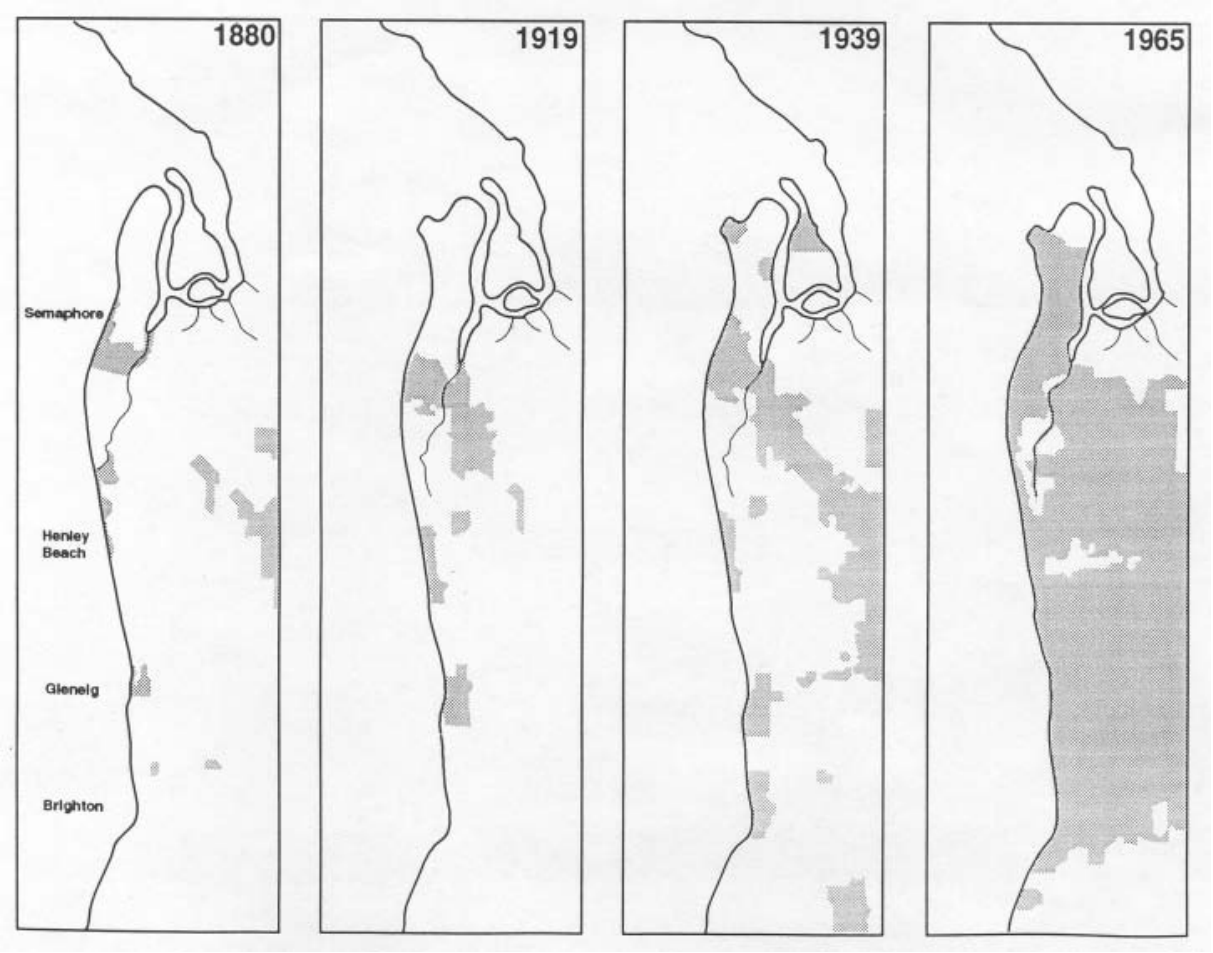
Formation of the Sand Dune System



Effect of Building on Metropolitan Sand Dunes

The service closed in 1880 with one of the reasons for its closure being given as the great difficulty in keeping the track free from drift sand.

Initial coastal development was concentrated at sites of landings and safe anchorages, being Largs Bay, Semaphore, Grange, Henley and Glenelg.



(Shaded areas represent urban development).

Urban Growth Along the Metropolitan Coastline

There was limited direct linkage between these locations in a north-south direction, but all areas were quickly connected to the city square by roads, and later rail and tramways. Coastal development tended to be by expansion of the isolated coastal nodes, with the frontal buildings being primarily shacks. This pattern of development remained for about the first 80 years.

Around the 1920's the coastal towns of Henley and Grange, and Semaphore and Largs had expanded to such a size that they began to merge into two separate linear coastal developments. Glenelg had expanded toward Brighton, which had by then developed into a further coastal node. This pattern of growth continued along the coast until World War II. During this time direct access by road was developed along the coast between these areas. The frontal buildings were still primarily shacks, but the value of coastal views and access to the beach had prompted more substantial buildings to be located closer to the beaches.

The post war period has seen almost complete development infill of the metropolitan coast between Kingston Park and Outer Harbor, as residents have chosen to live and build close to the sea. Generally, this has been rectangular ribbon development with an esplanade road between the foreshore and low rise single allotment dwellings. It is interesting to note that such form of development would not be permitted today given the current planning legislation and Coast Protection Board policies. The development of the dune system has in effect "locked up" the bulk of this finite sand source and has led to accelerated erosion of the foreshore. A consequence of this action was observed during the major storms in April 1948, May 1953, May 1958, May 1960, and July 1964 where wide spread coastal damage resulted to coastal properties.

These storms prompted Local Councils to build expensive and visually intrusive storm protection walls in order to prevent further property loss. While these structures conformed with the technology and philosophy at that time, they in fact accelerated the erosion problem even further. Many of the first structures were built by Local Councils or the South Australian Harbors Board with little overall co-ordination. They were vertical or concave concrete wails which reflect the wave energy back on incoming waves. In effect, these concentrated the local wave energy, particularly during storms, which increased the natural erosion rate and longshore sand movement.

Many of these wails were destroyed or have subsequently been removed or replaced with rock rip-rap" walls. These are sloping rock walls which have the capacity to dissipate wave energy rather than reflect and magnify it like the vertical concrete walls. There is currently about 5 kilometres of "rip rap" rock walling along the metropolitan coast. Its primary function is as a last defense against storm attack to prevent loss of property.

Rip-rap Wall - North Glenelg

Sea-wall at Broadway, Glenelg After Storm

UNDERSTANDING THE COASTAL PROCESSES

Since the major storms in the 1940's, 50's and 60's there has been considerable research undertaken on the metropolitan coast in an attempt to better understand the natural coastal processes. The coastal processes occurring in Gulf St Vincent are quite complex. The Gulf is relatively shallow, with the deepest parts being up to 40 metres below current mean sea level. It joins the Southern Ocean through Investigator Strait and the deeper but narrower Backstairs Passage. These restricted entrances act to attenuate the large ocean swells entering the Gulf. The effect of the ocean swell which does enter the Gulf varies along the coast

which does enter the Gulf varies along the coast depending on the effects of refraction past landforms, attenuation due to the seabed friction and shoaling. By far the greatest coastal damage results from winds blowing across the Gulf waters. These winds generate waves which attack the coast, cause water to bank up or elevate near the coast as a storm surge, and can lead to loss of sand from the active beach zone and dunes formed by aeolian sand movement. For the Adelaide coast the predominant winds are those from the south west, although it should be noted that there are occasionally strong north westerly winds. This variation in direction of wind driven waves means that the coastal processes vary from year to year, but the dominant south westerly winds lead to a net drift of sand in a northerly direction along the metropolitan coast.

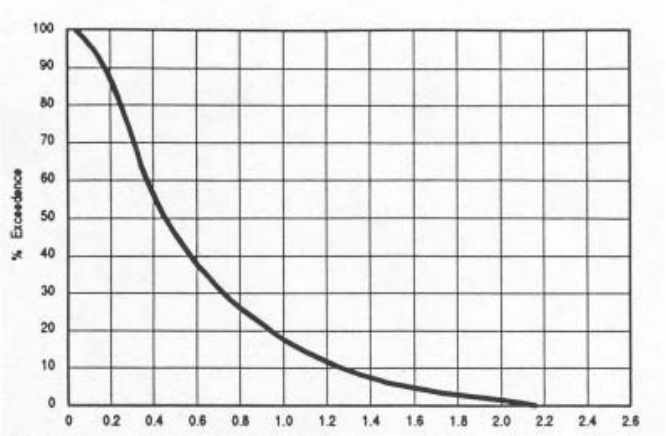
The waves generated by these winds are low to medium energy waves. The longest record of wave data for the metropolitan coast has been obtained offshore from Seacliff. This data indicates

Predominant Wind Direction

that the significant wave height exceeds 2 metres for only 1-2% of the time, while 0.5 metre significant waves occur about 50% of the time. A significant wave height being defined as the average height from peak to trough of the one-third highest waves. The maximum waves are about 1.8 times the height of the significant wave height.

These waves strike the metropolitan coast at an oblique angle and induce a coastal process known as littoral transport. In effect, littoral transport is the movement of sediments in the nearshore zone by waves and currents. When the waves strike the beach at an oblique angle, the sediment is worked along the beach by the wave energy. On the metropolitan coast this results in a net northerly drift. ~

This littoral drift is evidenced by the large accumulation of sand in the Outer Harbor area and

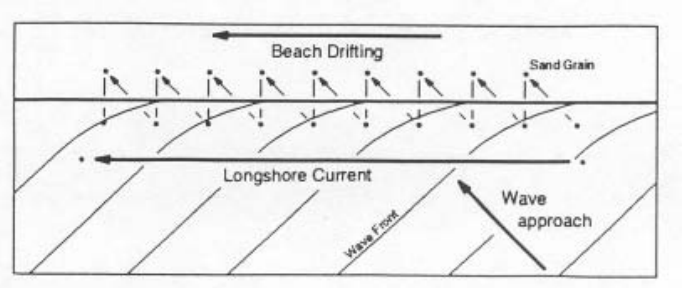


Wave Exceedence - Seacliff

on the southern side of obstructions on the coast, such as the groynes at Glenelg and North Haven. It is estimated that the net average northerly annual rate of littoral drift is between 30,000 and 50,000 cubic metres. This estimate includes the effects of the current ongoing sea level rise.

These coastal process have been occurring along the metropolitan coast for the last 6,500 years. However, it is only since the 1940's, when substantial development occurred on the sand dune reserves, that this problem has become a major concern to the metropolitan coast. It is interesting to note that even as late as the 1960's the finite nature of the sand source was poorly understood as evidenced by the commercial sale of sand trapped by the Glenelg groyne which was constructed in 1964.

In the 1960's the metropolitan Seaside Councils Committee together with the State Government, commissioned the University of Adelaide to conduct a detailed study of the metropolitan coast. The purpose was to provide a better understanding of the coastal processes and the problems of erosion of the metropolitan beaches. This detailed Erosion Report published in 1970, commonly referred to as the Culver Report after its primary author Dr Bob Culver, concluded that the basic problem with the beach system was that there was no naturally continuing replenishment source of sand. When this is combined with a net northerly littoral drift and an increasing mean sea level, the long term effect is the need to artificially maintain the beaches, or eventually lose them.



Littoral Drift

The Culver Report recognised the need to act urgently to artificially maintain the metropolitan coast as well as provide adequate storm protection for properties constructed on the dune system. It recommended the establishment of the Coast Protection Board, which was constituted under the Coast Protection Act in 1972, to co-ordinate and facilitate these activities. Since its formation, the Board has continued its role in maintaining and protecting the metropolitan coast with the technical and administrative assistance of the Coasts and Marine Section of the Environment Protection Agency of the Department for Environment, Heritage and Aboriginal Affairs.

THE METROPOLITAN BEACH REPLENISHMENT STRATEGY

In the early 1980's, the Board commissioned several studies by consultants. The purpose of these being to investigate the most cost effective strategy for maintaining the metropolitan beaches and at the same time minimising the risk of storm damage to properties along the foreshore. The results of these were published in 1984 in the Board's "Adelaide Coast Protection Strategy Review". This extensive report concluded that trucking an average annual sand volume of about 100,000 cubic metres from the northern beaches to the southern ones was the most appropriate beach maintenance strategy. It also recommended that sea wall construction should be limited to replacement of existing seawalls, and should only be undertaken where adequate protection could not be provided by the beach replenishment program. This was the basis of the metropolitan coast protection strategy until 1988.

In 1988, the Board gained Cabinet approval to undertake a three year major replenishment program in order to supplement a number of locations deemed to be vulnerable along the foreshore. From 1988 to 1990, about 190,000 cubic metres of sand was trucked from Torrens Island to North Glenelg, and approximately 100,000 cubic metres was dredged ashore at North Haven and then trucked to Somerton. In 1990, based on a recommendation from the Board, the Government agreed to provide funds to undertake a trial dredging exercise. Approximately 100,000 cubic metres of sand was dredged from North Haven by the contracted dredge, the "Pelican", and pumped ashore at North Glenelg. Another trial was undertaken during 1991 by the "Pelican" pumping a further 190,000 cubic metres ashore at Brighton. During the three year period from 1988, the sand replenishment program averaged an annual volume of 200,000 cubic metres.

At the conclusion of this period, the Board reassessed its strategy options. The results were published in April 1992 in the Board's publication "Review of Alternatives for the Adelaide Metropolitan Beach Replenishment Strategy". This report is summarised in Coastline No 28. It concludes that the most cost effective means of maintaining the metropolitan beaches is to continue sand replenishment, but opts for the method of dredging sand from offshore sand sources rather than the previously used trucking operation. The dredging operation has the advantages of providing new sand into the existing system, providing a coarser grained sand which acts to slow the littoral drift process compared to finer grained sands, and reducing the hazard and noise effects to the public by having less trucking movements along the foreshore.

The sand replenishment strategy involves biennially dredging 200,000 cubic metres from offshore sand sources and pumping it ashore at southern beach locations, including North Glenelg. In addition, 60,000 cubic metres are trucked over short distances to Vulnerable locations on the metropolitan coast. This has a present day cost of approximately $1.3M per annum.

Sand Dredging Along the Metropolitan Coast

CONCLUSION

Since its formation in 1972, the Coast Protection Board has performed the important task of maintaining the metropolitan beaches and minimising the risk of storm damage to properties along the foreshore. By gaining a better understanding of the coastal environment and coastal processes, the Board has, with the assistance of Government funding, been able to develop a strategy for the management of the metropolitan coast. The development of the sand replenishment strategy has been achieved with the benefit of hindsight, continuing data collection, ongoing detailed research and the realisation that the system must be artificially maintained if it is to be ' retained for the pleasure and recreational benefits of future generations.

For further information, contact the Coasts and Marine Section of the Environment Protection Agency, of the Department for Environment, Heritage and Aboriginal Affairs.